

ONION SMUT.
PRELIMINARY EXPERIMENTS.

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ONION SMUT—PRELIMINARY EXPERIMENTS.

BY A. D. SELBY.

INTRODUCTION.

There are comparatively few persons who have not some knowledge of the methods commonly followed in growing onions. This vegetable is widely cultivated in our state, yet its culture on a large scale is limited to comparatively few districts which possess soils especially adapted to this crop, or in which particular branches of onions growing have been developed. One recalls readily the large fields of onion commonly grown upon muck land, notably in the swamps of many counties in northern Ohio. Similar development has occurred near Lake Erie and in the bottoms along the Ohio river. In general the onion crop is grown from seed. The bulk of the Ohio crop is produced from seed, planted in single drills in very early spring and often cultivated in considerable areas. The comparatively small proportion of the total yield produced from sets or from mother onions will become apparent to any one who investigates this subject. This last named method of propagation of onions is confined chiefly to the market gardeners, who seek to place upon the early market a liberal supply of young, green onions. Yet a still smaller area is devoted to growing small onions from seed; these are destined for use as sets. This set growing from seed is a branch of onion culture practiced in the vicinity of Chillicothe, where in the aggregate large areas are planted every year. In most districts more or less attention is devoted to the growing of onion seed. Perhaps little interest for the student of plant diseases would attach to the methods of onion culture, that is, whether grown from seed, sets or otherwise, were it not that the seedling onions are liable to attack by the onion smut fungus, *Urocystis Cepulae* Frost.

This fungus is conspicuous for its property of survival in soils where it may occur. Given, a soil infested with the spores of onion smut and let this be planted to onion seed and we have the conditions which are likely to yield a crop of smutted seedling onions. It has been established that only the young seedlings are susceptible to attack by smut fungi. It seems that it is only when the seedling plants are very young and the leaf sheaths are very tender that the germ tube of the smut spore is able to penetrate the plant and there produce the disease. Once within the onion seedling, the smut fungus continues its growth as a parasite and completes its development by the production of smut spores. These dark masses of spores are the conspicuous evidence of disease. Bear in mind, however, that only seedling onions may be attacked by smut. Onions grown from sets, or healthy mother onions, even in a smut infested soil, will not be attacked by the smut fungus. The tissue covering of larger onions appears to be firm enough to resist the attack of the smut.

ORIGIN AND GENERAL DISTRIBUTION OF ONION SMUT.

Thaxter has given us (Report Conn. Agricultural Experiment Station, 1889, pages 131-146) a summary of the history of onion smut in this country and in Europe. He concludes "that the onion smut may be indigenous in Europe, despite the circumstance that the economic and scientific notices of it are of American origin. Nor is it unlikely * * * that it may be a native of both continents. * * * It is quite safe to assume then, that the onion smut originated from some wild species of onion, since it is well understood that fungi, like other plants, are no exception to the universal rule that every organism is derived from other organisms like itself, and not spontaneously evolved from the ground or other substances."

In the report by Dr. Thaxter, already mentioned, we have an account of the injury resulting from onion smut in Connecticut with brief references to its occurrence in Massachusetts, Pennsylvania and Ohio. This disease is now known to occur also in New York, New Jersey and Delaware, and doubtless in many other states. It is clear that the amount of injury from onion smut will depend somewhat upon the branch of onion culture pursued in a given locality. Serious injury is reported for Connecticut and like conditions seem to hold good for Ohio. Since this is a type of plant disease likely to be transmitted to posterity, the general distribution of the fungus becomes a matter of importance, and it would appear that only the most careful attention to avoidance of the smut fungus will prevent its introduction into most of the districts famous for onion growing.

OCCURRENCE OF ONION SMUT IN OHIO.

It is difficult to state just when onion smut was discovered in Ohio; it has certainly been known for some years in the vicinity of Berea, where large onions were extensively grown from seed, and in the Chillicothe district, devoted to growing onion sets in like manner. At the former point onion smut became troublesome between 1886-90, while about Chillicothe it was slightly later in appearance but has been present for about ten years. I have seen no specimens of smut from other points in the state, although there may be other infected areas.

APPEARANCE OF SMUTTED SEEDLINGS.

The presence of smut in seedling onions is first indicated by one or more dark spots at various points in the leaves of the onion; these spots, especially when viewed by holding them between the observer and the light, exhibit a dark, opaque character in marked contrast with the remainder of the leaf. As growth proceeds these affected leaves die above while the dark spots are exposed as sooty, powdery masses by the decay of the surrounding leaves. All stages of disease from smut may be observed if one studies the seedling when in the field. Some die soon after infection, others survive for a longer time, while yet others continue to live despite the attack of the smut, and though showing many evidences of smut, survive until the time for harvesting the crop is reached. Doubtless other conditions than the fact of infection, such as lack of sufficient moisture, will cause earlier death and, conversely, abundant moisture may increase the resistance of the onion plant, largely by increasing its vigor. As shown in the cut (Fig. 1) where the onion seedlings survive for some time the smut will be found upon or within the bulb; either affecting the external layers, or attacking the inner layers, where its presence is scarcely obvious from without. The tendency of such smutted onions is to rot or dry up so that they are readily separated from the healthy ones. This is particularly true in the handling of onion sets and this fact greatly facilitates the separation of diseased sets.

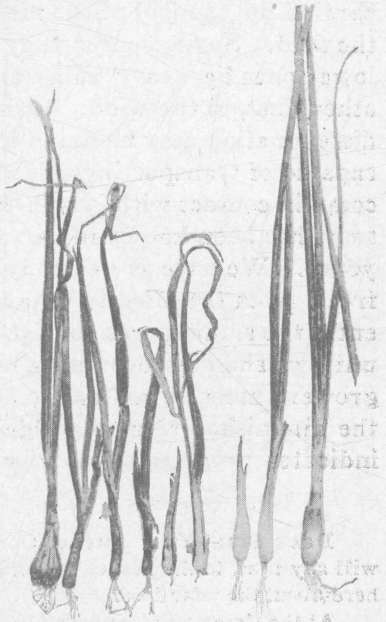


Figure 1. Seedling onions attacked by smut; healthy examples at right.

MANNER OF DISTRIBUTION.

As clearly stated, the fungus of onion smut attacks the young seedling onions, causing either their early death or their subsequent decay and the final removal of the onion bulb. Careful observation of the character of the disease shows us the error of the somewhat prevalent idea that the smut is disseminated in the onion seed. Such an idea is entirely without foundation. Since the seed onions, I might better say the mother onions, are not attacked by smut, the presence of smut spores in the seed need not be feared. Onion seed may, of course, become infected by adhering smut spores through careless handling in the district where onion smut prevails. This risk may be easily avoided in the growth of the onion seed. In the districts where no onion smut has been found we need not fear its spontaneous origin. If the smut occurs it must have come from without. This might happen in a variety of ways and when once introduced in a small part of the onion field its further dissemination is readily accounted for. The implements used to plow and prepare the ground may readily drag the smutted earth into the portion where the smut is still absent. The smutted soil may be carried on the feet of the men or animals engaged in working over the field. Some spores may also be washed from higher areas to lower ones by heavy rains and these spores may be also blown, like other dust, in the wind, during periods of drouth. Other causes of dissemination may be found in smut eating beetles and in any agency capable of transporting this sooty powder which may subsequently come in contact with earth not previously infected. Some onion smut has been known in certain parts of the state for more than ten years. We have as yet no record of soil once smutted having been freed from the disease by any method thus far employed. Apparently the smut spores survive in the soil for an indefinite period, and until we shall discover some means of preventing attack by the smut, growers must be content to abandon land once smutted or to expect the diminished returns yielded by such soils. The following letter indicates progress by rotation at Berea:

BEREA, OHIO, Nov. 5, 1900.

DEAR SIR:—Your letter of October 29th received; in reply to your inquiry will say that, to the best of my knowledge, the onion smut made its appearance here about the year 1888.

At the time you were here (1897) it was about the worst; since then we have rather gained on it by rotation of crops and plowing under rye. Rough green manure or straw is good; corn is the best for rotation. We are raising fairly good crops of onions on smutty land, although the smut is here to stay, we think.

Yours truly

O. L. SMITH.

BRANCH OF ONION GROWING IN RELATION TO SMUT.

Onion smut is injurious only to plants grown from seed sown in the soil where they are to grow to maturity; this will apply to the field-sown onions and not to any that may be transplanted. In case transplanting is practiced, it is easy to secure smut-free soil for the flats in which the seedlings are grown; after transplanting there will be no risk even in smutted soil. The smut problem is accordingly narrowed to the field culture of onions and of onion sets. As already intimated, onion growing is practiced in several portions of the state, particularly on muck and sandy soils.

The seed is sown in drills, twelve to fourteen inches apart, in earliest spring, the early sowing insuring a much better stand of seedlings. It is the aim for onions to secure such a stand as will insure the full development of the onions and a profitable yield. About five pounds of seed is sown per acre.

With the grower of sets the seed is sown so thick as to keep down the size of the onions by crowding. In both sorts of onion farming the hot suns of mid-summer cause the plants to mature and with them the bulbs. For sets in the Chillicothe district, upon sandy bottom lands, it is the practice to sow forty pounds of seed per acre. When a drill is used it is of a special design with force feed, planting five rows in about six inches, that is, with one and one-fourth to one and one-half inch inter-spaces. The distance between these groups of rows is usually about six inches. In this manner very thick sowing is attained.

Before the drills came into use it was the practice there to prepare a broad seed bed of about six inches in width, by rapid backward dressing with the hoe, and to sow the seed upon this bed-furrow, out of hand or by means of a hollow cylindrical drum mounted like a hand roller, the seed being discharged through the perforated covering of the cylinder. By these somewhat primitive methods, three operations are involved: First, preparation of broad depression for the seed; second, distribution of the seed, either by hand or with the drum, and third, covering the seed with the hoe. By the drill these three operations are reduced to the simple one of pulling the drill, properly supplied with seed, through the soil to be planted. None of these methods of seeding appear to have any considerable influence upon the amount of smut, but it is evident that the method of seeding may need to be modified to adapt it to remedies for smut prevention.

By the practices just specified, in the Chillicothe district four hundred to five hundred bushels of onion sets per acre could be grown under favorable conditions, previous to the appearance of the

smut. Since that time the yield has become reduced from twenty-five to forty percent or even more. When the tops show maturity, usually about the first of August, the set onions are pulled up and the bulbs lightly covered with earth, a few rows together, the tops and earth shading them from the sun. In this manner the ripening is completed, the tops wither and the sets are ready for sorting and screening (Fig. 3). The smutted sets are screened out when the whole have sufficiently dried and the product is then ready for storing. Although the smutted sets may appear nearly as large as the sound ones at pulling, these dry up very much more than the healthy bulbs. However, it scarcely appears probable that the sets from smutted soil will be entirely freed from smut; upon this point certain decisions of buyers may turn.

EXPERIMENTS IN PREVENTION OF ONION SMUT.

In May, 1890, attention was called to the presence of smut about Chillicothe by a letter from a set grower who recounted his experience in rotating the land for five years with other crops with the result that the smut was still present when it was again planted in onions. He also pointed out the ultimate destruction of the industry unless a remedy could be found for the smut, estimating that from 35,000 to 40,000 bushels of sets are grown each year in that district. Through the courtesy of this same grower, Mr. Fred Schreiner, Jr., two barrels of earth from badly smutted areas were shipped to the Station and placed in the Pathologium of the Botanist. Here small trials of remedies, including flowers of sulfur, earth saturated with formaldehyde (formalin) and the use of phosphatic fertilizers were made, but without decided result. Sprouting the onion seed before planting in the earth and covering with unsmutted muck soil gave somewhat more promise.

Conditions remaining as before, arrangements were made with Mr. Schreiner whereby the writer undertook to conduct some field experiments in cooperation with him, during the season of 1900. The plans were in nature preliminary and the experiments were conducted on two plots of ground, not very remote from each other. The north plot had been in onions two years before, with one year's rotation in other crops. The south plot, approaching garden soil in fertility, had been in other crops for about three years. The last previous crop of onion sets on each tract had been badly smutted, with small gradations in severity, according to the differences of soil.

The method of treatment consisted in using flowers of sulfur, one-fourth and three-eighths percent. solution of formaldehyde, salicylate of soda and salicylic acid, with and without lime, in contact with the seed; also stone lime, worked into the soil before seeding, on certain small areas.

The results of the test suggest the greater efficiency of solution of formalin to be applied in the manner hereinafter described. The opinion expressed by the growers of sets who followed the experiments are quite sanguine and are to a large extent apparently justified. This preliminary statement of the work upon onion smut is prepared with a view to securing more extended trial for the formaldehyde, or as more commonly called formalin, and the lime treatments on smutted soil.

The arrangement of plots and treatments were as follows:

MR. F. SCHREINER'S NORTH ONION PLOT—CHILLICOTHE, OHIO.
North.

1	Sulfur	+Lime 1	Seeder—Sulfur	1
2	Sulfur	+Lime 1	Seeder—Sulfur	2
3	Nothing	Lime 1	Drilled—Nothing	3
4	Nothing	Lime 1	Drilled—Nothing	4
5	Nothing	Lime 1	Seeder—Salicylic Acid & Lime	5 E.
6	Nothing	Lime 1	Seeder—Nothing	6
7	Formalin	+Lime 1	Seeder—Formalin	7
8	Nothing	Lime 1	Sal. Acid—Sal. Soda—S. A.—None	8
9	Nothing	Lime 1	Hand sown—Nothing	9

In this plot the rows are 170 feet long. To the limed portion from east side 87 feet; this was 10 feet across. Sulfur 12 lbs. on rows 1 and 2. Salicylic acid $\frac{1}{2}$ lb.; lime $2\frac{1}{2}$ lbs. on east portion row 5. Formalin 1 oz. in 3 gallons of water, sprinkled with rose on seed after sowing and immediately covered with earth except 40 feet west end row 7. Mixed treatment in row 8. Lime across all rows near middle.

MR. F. SCHREINER'S SOUTH ONION PLOT—CHILLICOTHE, OHIO.
North.

1	Formalin 75 feet—Nothing	Lime $\frac{1}{2}$	Sal. Soda—Nothing	Lime 1	Sal. Acid	1
2	Nothing	Lime $\frac{1}{2}$	Nothing	Lime 1	Nothing	2
3	Sulfur	Lime $\frac{1}{2}$	Sulfur	Lime 1	sulfur	3
4	Nothing	Lime $\frac{1}{2}$	Nothing	Lime 1	Sulfur	4
5	Sulfur and Lime	Lime $\frac{1}{2}$	Sul. & Lime	Lime 1	S. & L.	5

All rows of this plot seeded with seeder. Formalin on row 1; rate, 1 oz. Formalin in 2 gallons of water, applied on 75 feet of length. Sulfur on row 3, same rate as rows on North Plot. On row 5, sulfur and lime, each $3\frac{1}{2}$ lbs. No treatments of other sorts extend through lime plots, which receive respectively at the rate of about 150 and 75 bushels per acre of stone lime, slaked with water on the ground where applied.

SEEDING AND GERMINATION.

All the onion seed here applied was sown at the rate of 40 pounds per acre, and unless drilled, was sown on broad leveled rows five to six inches wide, with cylindrical seeder in parts so marked,

and scattered by hand when thus designated. The treatments applied, when in powder form, were distributed chiefly by means of a box attachment or hopper-like arrangement on this seeder. The formalin was sprinkled with watering pot, three gallons covering 135 feet of the row in the North Plot and two gallons 75 feet in the South Plot. In all these cases the seed was covered with hoe. In drilled rows the seed was distributed in the usual manner of drills, but it was found impossible to mix the seed and the powders for sowing in drill, as clogging resulted at every effort. It would appear that the application of such remedies as we have tried will involve hand seeding of the onions. Should a certain treatment come into use, such as the formalin devices for applying it will be possible and doubtless profitable.

Mr. Schreiner reported upon the germination of the onions, his observations indicating better stand on rows 1 and 2 than rows 3 and 4; a poor stand on row 5, better on row 6 and still better on row 7; also poor on row 8 and good on row 9 of the North Plot. No difference here on lime part.

On the South Plot the stand was reported altogether better than on the

North, except where salicylic acid preparations were used. The first report was made April 28, while on June 5 about half a stand with limited smut is reported for rows 1 and 2 of North Plot; better stand and more smut on rows 3 and 4; on number 5 a very poor stand; also poor stand on number 6; while on number 7, the formalin plot, the stand is best of all. The same treatment is recorded for the formalin row of the other plot and for the lime plots. The amount of smut is greatly reduced in the formalin and lime portions and somewhat reduced on sulfur rows.

It is quite apparent that certain treatments were unfavorable to germination; among these may be included sulfur to a slight extent, salicylic acid and salicylate of soda, and lime slaked by sprinkling water upon it after application.



Figure 2. Implements used in seeding. Onion seeder planting five rows, with roller in rear; also perforated cylindrical drum of tin with box attachment used in some of the work in the experiments.

Favorable influence to germination was exerted by formalin and possibly by liming. In this respect the yields will bear evidence of value. Since the weather was very dry for some months after planting, the unfavorable effects might not hold under other conditions of rainfall.

YIELDS FROM TREATMENT AREAS.

At my suggestion Mr. Schreiner gathered, sorted and separately weighed the sets obtained from the several rows under experiment. Since each row occupied a width of 12 inches the actual yields in pounds have been calculated to bushels of 50 pounds* per acre. These results bring out obvious advantages of the lime and formalin treatments.

In the North Plot the yields given for full rows are from a length of 125 feet, while in the South Plot these are for lengths of 75 feet.

* The smaller sets may more properly be calculated at thirty-five pounds per bushel; the larger ones at fifty pounds.

SUMMARY OF YIELDS—NORTH ONION PLOT.

Row.	Treatment.	Pounds.			Bushels per acre		
		Yield large or pickle onions	Yield sets.	Total.	Calculated yield large or pickle onions.	Calculated yield sets.	Increase or decrease in sets over untreated, bushels.
1 & 2	Sulfur	13	37	50	(45.3024)	128.93	-1.20
3 & 4	Nothing*	13	32	45	(45.3024)	111.51	.....
5	Salicylic acid and lime*	16	13	29	(111.5136)	90.60	-39.50
6	Nothing*	9	24	33	(60.7264)	167.30	.....
7	Formalin—.25 percent	15	26	41	(104.5440)	181.20	+51.11
8	Mixed—Salicylates*	27	9	36	(188.1792)	62.70	-67.40
9	Nothing*	21	26	47	(218.8454)	108.73	.....
Lime Plot	150 bushels of lime	21	35	56	(203.2800)	338.80	+208.70

SOUTH ONION PLOT.

1	Formalin, .375 percent .....	..	38	38	.....	441.41	+197.5
2	Nothing	15	22	37	(171.9168)	257.9	...
3	Sulfur	15	23	38	(176.5632)	264.8	+20.9
4	Nothing	13	20	33	(153.3312)	230	....
5	Sulfur and lime	17	26	43	(199.7952)	299.7	+55.8
East lime plot	150 bushels of lime	17	..	17	(296.208)	....	....
West lime plot	75 bushels of lime	15	..	15	(261.36)	....	....

*Sets here less valuable than from row seven.

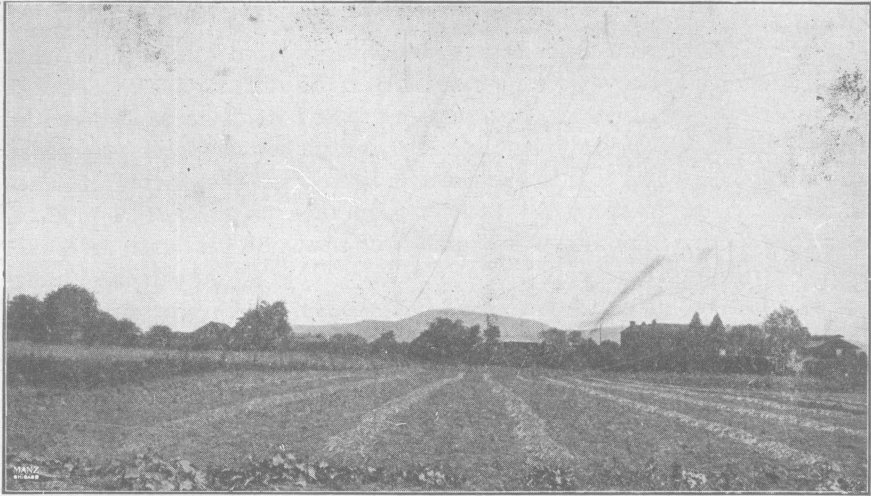


Figure 3. Mr. F. Schreiner's North Onion Field, 1900, showing set onions as placed when pulled; at the extreme left a new row is started.

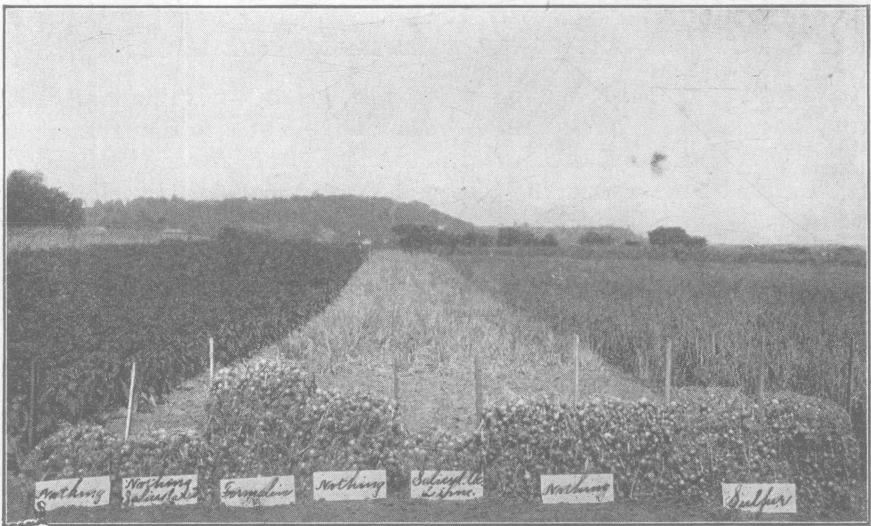


Figure 4. Photographic view of the results of onion smut experiments; the numbers of the rows of the table run from left to right in the figure.

DISCUSSION OF RESULTS.

It will be perceived from the first portion of the table, that while the two rows treated with flowers of sulfur gave an average yield of sets greater than the average of the two adjacent, untreated rows, these yields fall below the average of the three untreated rows, Nos. 3, 4 and 6. Above the averages of all the untreated rows in this section there still shows a gain, on sets only, of 51 bushels per acre where formalin was applied, or about 39 percent. increase. Row 9 without treatment, but differently seeded, also on the exterior of the area, gives a good yield, but should possibly be rated as of doubtful value for these reasons, in any comparisons to be made.

The nine rows of the lime plot receiving sulfur on two of them, formalin on one and nothing on the others in addition to the lime applied as stone lime and left to slake in the air, gave an increase of 208.7 bushels per acre or 160 percent.

On the South Plot the formalin gave the highest yield, obtaining an increase of 197 bushels per acre, or 81 percent.

The salicylic acid, salicylate of soda and other partial row tests were not kept in such a way as to enable definite statement; these substances prevented germination. Sulfur and lime on row 5 of the South Plot appear to have exerted a favorable influence. While by no means decisive in a final sense, formalin applied on the scattered seed and stone lime applied on the soil are worthy of further trial on an extended scale. The ground lime now on the market commends itself for this use.

SUGGESTIONS FOR PREVENTING ONION SMUT.

The suggestions arising from the brief study made of this subject relate to general field handling of sets and to the treatment of seed; in both cases the object is to reduce and prevent smut.

Under the first heading every method should be employed to reduce or destroy smut spores. To this end it would appear practicable to collect all refuse from the screening of the sets, either in shallow boxes or upon canvas and give these a baptism of fire sufficient to destroy the spores. This material, including tops, smutted sets and infected earth, would be greatly improved in this respect by burning.

Under the head of treatments to be applied in planting, formalin and stone lime are both promising, if the present season's results are found capable of repetition on a large scale. It would seem possible to increase the percentage of formaldehyde, of forty percent. strength, or formalin such as herein mentioned, to one-half percent. solution, or 1 pound to 25 gallons of water, or 1 ounce to 1½ gallons. Upon this point I would advise the use rather of a three-eighths percent. solution, 1 ounce to 2 gallons of water, for all save

smaller experimentation until the safety of a greater strength is established, likewise its greater efficiency, which can now only be inferred. This formaldehyde of 40 percent., or formalin, as usually called, put up in one pound bottles is now in the hands of most druggists and should not cost much more than fifty cents per pound; while in larger quantities, such as carboys and cans of several gallons capacity the price may be reduced to thirty-five cents per pound. A guarantee of 40 percent. formaldehyde should be required in purchasing this material. Since it is simply a gas absorbed in water to the strength just given, it will be readily understood that uniformity of strength is essential to uniformity of results and economy of purchase.

It seems necessary to apply the formalin solution in some manner as that before described, although there should be nothing incompatible with hand carts, sleds and the like in devices for making the rows and sprinkling the solution. Horse implements can scarcely be used at these stages because of the effect of trampling.

A barrel containing the solution and mounted upon a cart should prove a means of easily applying the formalin by rose (sprinkler) suitably connected. In the application of lime the usual methods of applying by spreading stone lime before slaking, or better, the ground burnt lime, should prove sufficient. It does not seem probable that more than one hundred and fifty bushels per acre will be required and a less amount may prove equally effective.

Where set growers have smut infected land to plant it is advised to use lime on one strip; formalin on another, and both together on yet another of equal area, alternating with at least two untreated strips of equal size to test field results.

SUMMARY.

This bulletin recounts something of the history of the onion smut fungus, *Urocystis Cepulae* Frost, in the United States and records its destructive occurrence at two points in Ohio.

This onion smut infests the soil into which it has become introduced and attacks onions growing from seed in such soil. It does not attack sound sets or mother onions.

The onion smut is not introduced into onion seed if properly handled, but much more probably in onion sets or infected onions. It may be spread in a variety of ways.

Preventive treatment and measures of avoidance seem necessary to preserve the onion set industry from abandonment in parts of the Chillicothe district.

The treatment measures indicated by the preliminary experiments recorded in this bulletin consist in the application of *stone lime* and in the use of forty percent. formaldehyde commercially known as *formalin*.

To apply formalin use at a rate of 1 pound formalin to $37\frac{1}{2}$ to 50 gallons of water (1 oz. to 2 or 3 gallons) and apply with sprinkler upon the scattered seeds until well moistened, then cover with earth promptly.

Apply stone lime after the usual methods, spreading before permitting it to slake, either in the usual form or finely ground soon before seeding upon the prepared land. Harrowing may follow, and immediately precede the seeding of this land. Ground lime admits of easier application without increase of cost.

Further experiments are needed to establish the commercial value of the methods herein indicated.

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